2.2.2. Controls and Displays

2.2.2.1. Purpose

The purpose of this test is to assess the suitability and utility of the radar controls and displays for the assigned mission as an interface between the operator and the radar system.

2.2.2.2. General[5]

As good as many radars are in determining the parameters of the target, they have failed if the operator is not presented with a usable display or if the operator is not given adequate controls to operate the system. The controls and displays must be usable in every conceivable flight regime, ambient lighting condition, weather condition, and by aviators with the range of anthropometric measurements for which the system was designed to operate. For the modern fighter or attack airplane this is usually all weather, day or night, around +9 to -4 g's, for the 3 to 98 percentile groups, and in a realistic tactical environment filled with urgent decisions demanding the aviator's attention. For this reason, the controls and display should require an absolute minimum of operator input or interpretation and the information imparted and required from the operator should be a minimum and precisely what the aviator needs to execute the current phase of flight.

Controls should be easily manipulated wearing the proper flight clothing. The range of control (both the physical range of movement of the knob, dial, lever, etc. and the range of effect that the control has on the radar) and sensitivity should be compatible with the expected flight regime. Controls that require manipulation while airborne should be reachable from the DEP, particularly if they must be activated in a combat environment. As an example, the Air Combat Maneuvering (ACM) Mode controls must be reachable while performing high g maneuvers and while maintaining a body position ready for safe ejection. The operative sense must be correct. The direction of activation should conform to the standards of common sense (turn the knob to the right to turn on the system) and to the standards set in references 15 and 16 (which for the most part merely put on paper the standards of common sense). The operation of the controls should be clear, requiring a minimum of operator concentration and attention. This leaves the operator free to make tactical decisions.

The controls should also be placed in logical functional groups, reducing the area of scan required to check the radar set up. The radar controls should be integrated well into the cockpit. Correct integration requires that the radar controls should operate harmoniously with the other controls within the cockpit and without hindering the simultaneous operation of other airplane systems. Integration must be evaluated during a mission relatable workload and while simultaneously operating all the other airplane systems, since good radar work is usually just a part of the mission.

Lastly, the controls should provide good tactile feedback. For example, detents should provide the proper amount of "click" and all the knobs shouldn't feel exactly alike when reaching for a control with eyes on the radar scope. Applying a little common sense and manipulating the controls in a mission relatable environment usually uncovers most of the control human factors violations.

Many modern aircraft have a large number of the avionics controls included in the Hands-On-Throttle-And-Stick (HOTAS) format, allowing manipulation without releasing the throttle and stick. These implementations have their own human factors challenges. Typical problems include the mounting of too many controls in the available area, appropriate control sensitivity across broad flight conditions and tactile feedback considerations.

The radar displays should be clearly visible from the DEP in bright daylight as well as complete darkness. In bright daylight, the display must be usable under all conditions of glare, including sunlight directly over the operator's shoulder onto the display (a particularly serious problem for most displays). In the dark, the display should not be so bright that it distracts the operator or affects his night vision. A good range of

[5] For an introduction into controls and displays human factors, see references 20, 54 and 73.

brightness control that integrates harmoniously with the rest of the cockpit is required.

The display resolution must be matched to the radar resolution. That is, the raster lines per inch versus the range scale relationship presented in equation 6 must not limit the theoretical resolution of the radar presented as equation 1. The display must refresh itself quick enough so that the symbology, alphanumerics and video present an even and continuous display without noticeable flicker. There should be no visible delay between the radar sweep passage and the update of the symbology, alphanumerics and video.

Alphanumerics must be clear and legible. The messages should be short and easily understood without excessive coding or operator interpretation. The information displayed to the operator including video, symbols and alphanumerics must be sufficient for the current phase of flight while at the same time not overloading the operator with information. This usually requires tailoring the display to the specific attack mode/mission/phase of flight, that is currently being used. The display should be assessed for the information load in a mission relatable scenario to determine its utility as an aid in the combat environment. It is unlikely that a display compatible in size, weight, power and cooling requirements with a tactical airplane will be built in the near future that has too large of a usable display face. Thus, the display should be evaluated for size in a relatable mission environment, accounting for this element of realism.

The display should be positioned in a location suitable for the mission. As an example, a display for a radar that includes ACM modes should be high on the front panel, or even on the Head Up Display (HUD), to allow the pilot to glance down or look through the HUD and gather the radar derived information while at the same time minimizing the time he or she spends with his or her eyes in the cockpit and consequently away from a visual scan for the target. As with controls, display human factors problems typically surface by applying a little common sense while using the radar in a mission relatable scenario.

2.2.2.3. Instrumentation

A tape measure and data cards are required for this test. A voice recorder is optional.

2.2.2.4. Data Required

Qualitative comments. Evaluator's anthropometric data and a list of personal flight gear worn must be recorded. The number of display raster lines per inch and range scale limits should be obtained from the radar technical manual. The usable display area should be measured. Location of the display from the DEP should be measured if a qualitative problem is noted. Record the reach length of controls that are beyond the operator's reach while seated at the DEP during any mission relatable scenario.

2.2.2.5. Procedure

Find the DEP as outlined previously. All ground and airborne tests should be performed while at this position and wearing a complete set of flight gear. Perform a system turn up on the ground outside of the hangar in a range of ambient lighting conditions (bright daylight to darkness which may be simulated using a canopy curtain). Manipulate all controls noting the factors discussed above. Measure the display usable area. Evaluate the display for the factors discussed above.

Measure and note the position and reach length to all controls and displays that pose a visibility or reach problem from the DEP. During airborne testing, manipulate the controls and make qualitative comments during mission attacks and intercepts. Take particular note during extremes of ambient lighting for displays and during high g maneuvers for controls. Confirm the results of the ground tests while airborne. Check the extremes of control limits and sensitivity. Repeat for each test flight.

2.2.2.6. Data Analysis and Presentation

Present a table of the operator's anthropometric data and the personal flight equipment worn during the tests. Present the seat position as the number of inches from the bottom of the seat travel. Relate the sensitivity of the controls to the tactical environment in which they are to be used. For example, a fighter's brightness potentiometer knob may be too sensitive to use under moderate g or turbulence making it unusable during intercepts and ACM.

Relate the accessibility, placement and grouping of the controls under mission relatable conditions. An ACM mode selector must be readily accessible while scanning outside the airplane and maneuvering violently. Relate the control clarity, operative sense and tactile feedback to a multiple threat, combat scenario requiring the operator to make quick tactical decisions. If ambient lighting affects the display in any way, relate this to the limits of the possible combat environments. Compare the minimum display resolution given in equation 6 with the minimum radar resolution given in equation 1. The display resolution should not limit the radar resolution.

Relate the information load presented the operator to the combat scenario discussed above and evaluate whether the needed information is present and whether too much information is cluttering the display. This information can include radar video, alphanumerics or symbols. This concept is closely related to the size of the display face usable area. A large scope can present more information without cluttering the display and requires less concentration to read and evaluate, especially in the case of radar video. The refresh rate should be related to the concentration required to evaluate a flickering display. The display position should be evaluated in the context of the type of information displayed, the eye position required for using the display and the display position's effect upon the scan of other displays, instruments and the outside world.

2.2.2.7. Data Cards

Sample data cards are presented as cards 3 and 4.

CARD NUMBER ___

CONTROLS

CLARITY OF OPERATION:

ACCESSIBILITY (MEASURE REQUIRED REACH IF A PROBLEM):

OPERATIVE SENSE:

ADJUSTMENT SENSITIVITY:

RANGE OF ADJUSTMENT:

TACTILE FEEDBACK:

FUNCTIONAL LOCATION/GROUPING (SKETCH IF A PROBLEM):

INTEGRATION:

Card 3: Controls Data Card